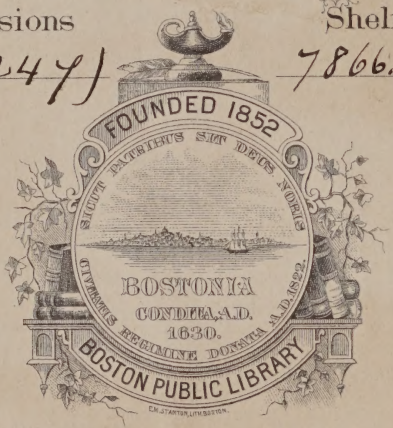
BOSTON PUBLIC LIBRARY
3 9999 08657 107 0

1313

Accessions
(21247)
Shelf No.
7866.44



Received, Oct. 18, 1890.

21247

[*Extracted from Appalachia, Vol. IV., No. IV.*]

OCT 10 1890

Heights of the White Mountains.

By Edward C. Pickering.

During the summer of 1876 several thousand measurements were made of the altitudes of various points in the White Mountains. A brief description of this work has already been given in Appalachia, Vol. I. p. 138. The method of zenith distances was employed, the measurements being made by means of a micrometer level. This instrument consists of a telescope to which a delicate level is firmly attached. A micrometer screw serves to raise or lower one end of the telescope, the other end being attached to the base by a hinge. A further discussion of this instrument may be found in the "Proceedings of the American Academy," Vol. XI. p. 256; Vol. XXI. p. 268. Thirty-four stations, most of them mountain summits, were occupied with this instrument in 1876. Measures were made from each station, by directing the telescope to each mountain summit or other object of interest visible, and reading the micrometer screw. At short intervals during this work the instrument was levelled, and the screw again read. Horizontal angles were also measured in order to identify or locate the points observed. To determine the altitude of a given point above the instrument, we must know its angular altitude and its horizontal distance. For want of this last quantity the reduction of the observations described above has been delayed for several years. The preparation of the new Appalachian map of the White Mountains has furnished the means of determining these distances, and has accordingly been employed for this purpose. The horizontal angles have been verified at the same time, and in fact have served to locate many of the observed points. The danger of an error in identification has thus been greatly diminished.

The original readings of the micrometer screw were made to the nearest whole division of the divided head, — that is, to one hundredth of a turn. Later observations have shown that each division, which equals about 14″, should be divided into tenths, to attain the greatest accuracy of which the instrument is capable. The effect on the final result is not,

however, important on account of the presence of other sources of error. The most important of these are: First, variations in the atmospheric refraction; secondly, changes in the instrument, caused by variations in temperature, especially when it is exposed to the sun; thirdly, deviation of the point observed, from the true summit. In many cases the summits measured were wooded, the tops of the trees being observed. The mountains were seldom so flat or so near that a point below the summit would be sighted upon by mistake. This source of error would affect the horizontal angles much more than the vertical. It rarely happened that a signal had been erected on which all the pointings could be made. For ordinary purposes an error of a few feet in the height of a mountain is unimportant. To reduce the readings of the micrometer screw, three quantities must be determined: first, the combined collimation and level error of the instrument, which may be defined as the angle between the level and the telescope, or the inclination of the telescope when the level is horizontal; secondly, the correction for the curvature of the earth and the atmospheric refraction; thirdly, the angular value of one division of the micrometer screw. Each of these quantities may either be measured directly, or derived from the observations themselves. In the present case the latter method has been employed. A large number of reciprocal readings were obtained, since, in general, from each station pointings were made upon all the other stations visible. The difference between two reciprocal readings equals twice the sum of the first and second of the errors, — that is, the sum of the collimation, level, curvature, and refraction errors, — provided that these quantities are the same at the two stations. But the combined curvature and refraction expressed as an angle is nearly proportional to the distance between the points of observation, while the collimation and level errors are, of course, independent of this distance. A comparison of fifty-three pairs of reciprocal readings showed that the collimation and level errors were nearly equal to two divisions of the screw, and that the curvature and refraction equalled about one division for each kilometre of distance between the points of observation. The variation

for different stations did not appear to exceed the other sources of error enumerated above.

The angular value of one division of the micrometer screw may be determined from the observation of any point whose distance and height above the instrument are known. Observations were made between but few pairs of stations, both of which had hitherto been determined with sufficient precision. It was decided, therefore, to employ all pairs of observations which served to determine the height of any station from two others, one high and one low, provided that the height of these last had been determined by levelling.

TABLE I. — Stations Occupied.

No.	Desig.	Name.	Vert.	Horiz.	Cl.	Height.
1	—	Israel River Bridge	30	27	F	—
2	—	Plaisted House (piazza) . . .	65	56	D	1396
3	—	" " (window) . .	241	67	D	1406
4	—	R. R. Bridge, Lancaster . .	43	43	F	—
5	—	Hill near Jefferson	32	31	F	—
6	E. 9.1	Bray's Hill	105	107	D	1633
7	—	Jefferson Hill	67	62	F	—
8	D. 16.1	Ball (Boy) Mountain . . .	75	74	D	2233
9	D. 12.1	Starr King	118	115	D	3925
10	E. 4.2	Owl's Head	146	135	C	3270
11	F. 3.1	Mt. Adams	223	215	B	5819
12	—	Mt. Pleasant House	40	34	E	—
13	—	Mrs. Pendexter's, N. Conway	71	57	F	—
14	—	Intervale Station	20	15	A	549
15	P. 1.1	Kearsarge (N.)	194	178	B	3270
16	F. 9.1	Mt. Pleasant	123	109	C	4781
17	F. 6.1	Mt. Washington	70	66	A	6293
18	F. 4.1	Mt. Jefferson	260	208	C	5736
19	—	Twin Mountain House . . .	64	53	F	—
20	—	Flume House	18	20	F	—
21	I. ?	Mt. Pemigewasset	76	70	D	2561
22	J. 6.1	Mt. Lafayette	185	164	C	5269
23	J. 7.1	Mt. Liberty	172	151	C	4472
24	M. 4.2	S. Doublehead	139	111	E	—
25	O. 1.1	N. Moat	200	184	B	3217
26	O. 1.4	S. Moat	87	85	B	2788
27	Q. 1.1	Chocorua	119	113	B	3508
28	—	Conway Corner Station . . .	27	24	A	466
29	M. 5.1	Thorn Mountain	155	138	E	—
30	K. 4.1	Mt. Willey	197	190	C	4313
31	—	Glen Station	53	48	E	529
32	—	Bemis Station	7	11	E	995
33	—	Upper Bartlett Station . . .	28	26	A	659
34	L. 14.1	Iron Mountain	83	80	C	2736
35	—	Thorn Mountain House . . .	41	37	E	—

The various stations occupied are enumerated in Table I., which gives in successive columns a number for reference, the Appalachian designation, if any, for the station, its current name, the number of vertical and of horizontal angles measured from it, and a letter which designates the class to which it was assigned in the determination of its height. A indicates that the height was determined by levelling. B, C, and D refer to the classes described below in the determination of the heights of the occupied stations. E is applied to other stations whose positions have been found, but whose heights were not used in determining the heights of the other stations. F is applied to those stations whose positions have not yet been determined. The last column gives the height finally adopted for each station. A further description of the stations is given below.

1. The instrument was mounted on the rail of the bridge where the road from Jefferson Hill to Cherry Mountain crosses Israel's River.

2. Near the southern corner of the piazza on the floor of the parlors.

3. Window facing southeast of the room in the eastern corner of the second story.

4. Fifty yards northeast of the bridge of the Boston, Concord, and Montreal Railroad over Israel's River in Lancaster.

5. Ledge on the hill about two miles east of Jefferson Hill.

7. Rock on the hill-side behind Waumbek House, about five hundred feet above it.

12. Window over the front door in the second story.

13. Window-sill in the second story of the house two hundred yards west of Intervale Station.

14. The height of the rails at this station, as also of Nos. 31, 32, and 33, was furnished by the courtesy of John F. Anderson, Esq., Chief Engineer of the Portland and Ogdensburg Railroad Company. They have been diminished by five feet to reduce them to the sea-level at mean tide. The following elevations above mean tide are derived from the same source, and may be valuable for future reference: Line of Bartlett and Hart's Location, 744; Crossing of Sawyer's River, 860; Crossing of Nancy's Brook, 969; Water station at Cow's Brook,

1,455; Station for the Willey House, 1,607; Summit of grade at Crawford's Station, 1,902; Fabyan House, 1,571.

15. Two stations were occupied, as the house on the top prevented an unobstructed view.

17. Elevation determined by the United States Coast Survey (C. S. Report, 1870, p. 90).

19. A knoll between the hotel and railroad.

20. Window-sill in the Flume House facing east in the second story.

24. As trees partially obstructed the view from the top of this mountain, the Coast Survey signal had been erected a short distance from the summit. The station occupied was near this. Unfortunately the position of the signal had not been determined, and its location cannot now be found. As it could not be seen from a distance, reciprocal readings could not be obtained.

28. Elevation determined by levelling ("Geology of New Hampshire," Vol. I. p. 265).

29. As the summit of this mountain was wooded, three stations were occupied on it at some distance apart. For this reason it has not been used in determining the heights of the other stations.

31. See No. 14. Three stations were occupied, as an unobstructed view could not be obtained from either one. For this reason it has not been used in determining the heights of the other stations, although its own height was determined by levelling. The results derived from it by a preliminary computation were somewhat discordant, probably from the shortness of the horizontal distances of the stations observed.

32. See No. 14. Not used in determining the height of the other stations, although its own height was determined by levelling. Its position had not been determined when the computation was made, and No. 16 is moreover the only station visible.

33. See No. 14.

The height given for Mt. Washington, No. 17, is that of the Coast Survey bolt, which was covered by a cairn at the time these observations were made, and now has a tower

erected over it. It is assumed to be the same as the apparent height of the ground around the hotel. Sightings were also made upon the ridge of the hotel from ten stations, and on the top of the chimney connected with the steam-boilers from six stations. Giving weights proportional to the distances of the points of observation, these points were found to be, respectively, 36 and 41 feet above the points observed on the ground. The measures from Mt. Adams and Mt. Jefferson have the greatest weights. The intervals to be measured there equalled nearly half a turn of the screw.

Nine measures of the cupola of the house on Kearsarge (N.), No. 15, in like manner gave its height as 35 feet above the ground. This house has since been destroyed by fire.

Table II. contains the material from which the angular value of one division of the screw was determined. In two cases only was a direct measure made between two stations both of which had been determined by levelling. It seemed best, therefore, to include all those cases where the difference between two such stations could be determined by observations made to or from any intermediate station. Calling the lower, intermediate, and upper stations L, M, and N, respectively, all cases must be considered where L M and M N have been measured by the micrometer level, if L and N have been determined by levelling. The first and second columns of Table II. give the names of the lower and intermediate stations. The upper station was Mt. Washington in each case. In the third column u denotes that the observation was made looking up from the lower to the intermediate station, d that the observation was made in the opposite direction. When observations were taken from each of a pair of stations, two lines are given in the table, since the observations were made on different days and are wholly independent. The next two columns give the number of measures of the line L M, and the mean resulting differences in height, assuming from a preliminary discussion the mean value 0.227 for one division of the screw. The unit is such that this represents the fraction of a foot corresponding to one division of the screw at a distance of one kilometre. The next two columns represent the number of measures along the line M N, and the resulting difference in height. All

of these measures were made from M to N, and none in the opposite direction. The next column gives the difference in height of L and N as determined by levelling, and the last column but one gives the residual found by subtracting this difference in height from the sum of L M and M N given in the preceding columns. When several measures are made of the same line they are seldom successive settings upon the same object. They are generally either settings upon different points, as the ridges and bases of the hotel on Mts. Washington and Kearsarge, or they are settings taken at considerable intervals, other measures being made meanwhile. The final column gives the value of one division of the screw derived from each measure.

TABLE II. — Fundamental Altitudes.

L.	M.	D.	No.	L M.	No.	M N.	Elev.	Res.	Div.
Conway Corner	—	u	4	5836	–	—	5827	+9	0.2274
" "	Adams	u	1	5351	3	470	"	–6	0.2268
" "	Chocorua	u	1	3040	2	2777	"	–10	0.2266
" "	Kearsarge (N.)	u	3	2814	8	3032	"	+19	0.2278
" "	N. Moat	u	1	2746	3	3076	"	– 5	0.2269
" "	S. Moat	u	1	2319	1	3503	"	–5	0.2269
Intervale	Kearsarge (N.)	u	2	2705	8	3032	5744	–7	0.2268
"	" "	d	1	2713	3	"	"	+1	0.2270
"	N. Moat	u	1	2685	3	3076	"	+17	0.2274
"	" "	d	1	2667	3	"	"	–1	0.2270
"	S. Moat	u	1	2266	1	3503	"	+25	0.2280
"	" "	d	1	2250	1	"	"	+9	0.2272
Upper Bartlett	Kearsarge (N.)	u	1	2599	8	3032	5634	–3	0.2269

The first measure in the table is a direct observation of Mt. Washington from Conway Corner. As no intermediate station was used the columns relating to M are left blank. A measure of Mt. Washington from Glen Station gave a residual of — 8, and the resulting value of one division, 0.2268. The mean of the thirteen values given in the last column of the table is 0.2269, and this value would be somewhat increased if we give greater weight to the observations depending upon the greatest number of settings. The value 0.227, which corresponds to the angular value of 14.″27 for one division of the micrometer, has therefore been adopted.

The heights of the intermediate stations contained in

Table II. are determined with considerable accuracy, since each of them has been compared directly with a station above, and at least one below, whose heights have been determined by levelling. These stations are designated as B in Table I. From Classes A and B the heights of several other stations may be determined; these form Class C. Class D in like manner is formed from A, B, and C. All the more important stations are included in this list, except Nos. 24 and 29, regarding which some uncertainty exists. Several of these heights, however, depend upon a small number of measures, and the accidental errors are likely to be increased by the fact that they are connected with the levelled station only through one or two intermediate stations. A second approximation has therefore been made by determining the height of each station in B, C, and D from each of the observations connecting it with the stations A, B, C, and D, adopting the values just found for the stations B, C, and D, and using the levelled heights of A. The mean of these gave a third approximation to the heights of these stations. A fourth approximation was made in the same way, but did not alter the previous values by a sensible amount.

The results of the successive determinations of the heights of the stations in Classes B, C, and D are contained in Table III. The successive columns give the number of the station, its name, the number of readings employed in the first approximation, the deduced altitude, the average deviation in feet of the separate results, and the probable error of the mean in feet. The correction required by the second approximation is given in the next column, a negative sign denoting that the first result appeared to be too large. The corrections required by the third and fourth approximations are given in the next two columns. The last four columns relate to the value of the height finally adopted. They give the number of settings, their mean result, the average deviations of the separate readings, and the probable error of the mean as indicated by the accordance of the individual values. The three classes B, C, and D are placed in successive portions of the table, and each is followed by a line giving the means of certain of the columns.

TABLE III. — Heights of Stations.

No.	Name.	No.	I.	A. D.	P. E.	II.	III.	IV.	No.	Adopt.	A. D.	P. E.
						Class B.						
11	Adams	5	5821	1.2	0.5	−2	0	0	27	5819	7.6	1.2
15	Kearsarge (N.)	17	3262	7.0	1.5	+9	−1	0	45	3270	11.0	1.4
25	N. Moat	6	3220	5.7	2.1	−2	0	−1	31	3217	10.1	1.6
26	S. Moat	4	2797	9.8	4.6	−9	0	0	20	2788	11.0	2.1
27	Chocorua	3	3513	5.0	3.0	−5	0	0	30	3508	8.2	1.3
	Mean	7.0	—	5.7	2.4	5.4	0.2	0.2	31	—	9.6	1.5
						Class C.						
10	Owl's Head	8	3273	2.0	0.6	−2	0	−1	22	3270	5.2	1.0
16	Pleasant	11	4781	8.9	2.4	+1	0	−1	27	4781	6.9	1.2
18	Jefferson	6	5738	0.8	0.3	−2	0	0	24	5736	6.3	1.1
22	Lafayette	17	5271	13.1	2.8	−3	+1	0	31	5269	13.3	2.1
23	Liberty	8	4464	12 9	4.1	+9	−1	0	20	4472	11.7	2.3
30	Willey	10	4311	14.2	4.0	+2	−1	0	21	4313	10.2	2 0
34	Iron	9	2741	12.4	3.7	−3	−2	0	10	2736	10.6	3.0
	Mean	9.9	—	9.2	2.6	3.1	0.7	0.3	22	—	9.2	1.8
						Class D.						
3	Plaisted	7	1407	6.9	2.2	0	−1	0	7	1406	6.9	3.4
6	Bray	9	1634	6.3	1.9	0	−1	0	10	1633	5.3	1.5
8	Ball	10	2234	11.4	3.2	0	−1	0	10	2233	11.5	3.2
9	Starr King	15	3925	7.2	1.6	0	0	0	16	3925	5.9	1.2
21	Pemigewasset	6	2560	14.5	5.5	0	+1	0	6	2561	10.8	4.1
	Mean	9.4	—	9.3	2.9	0.0	0.8	0.0	10	—	8.1	2.7

An examination of this table shows that the successive approximations give a rapid approach to the final value. The mean values in feet of all the numbers contained in Columns II., III., and IV. are 2.9, 0.6, and 0.2. Another approximation would not change any of the adopted values by one foot. The total number of settings in the table is 357 and of stations 17, or an average of 21 to each station. The average deviation of the separate results has a mean value of very nearly 9 feet, and the probable error of a mean elevation is 2 feet.

To show the degree of accordance indicated by Table III., the observations of one station, North Moat, are given more fully in Table IV. A number for reference is followed by the

number and name of each station serving to determine the height of North Moat, the resulting altitude, and the residual found by subtracting the mean value 3,217.

TABLE IV. — North Moat.

No.	Des.	Name.	Elev.	Res.	No.	Des.	Name.	Elev.	Res.
1	11	Adams	3253	+36	17	26	S. Moat	3220	+3
2	"	"	3224	+7	18	"	" "	3214	−3
3	14	Intervale	3215	−2	19	27	Chocorua	3204	−13
4	"	"	3234	+17	20	"	"	3206	−11
5	15	Kearsarge (N.)	3194	−23	21	"	"	3204	−13
6	"	"	3208	−9	22	"	"	3216	−1
7	"	"	3205	−12	23	"	"	3221	+4
8	"	"	3205	−12	24	"	"	3229	+12
9	16	Pleasant	3231	+14	25	28	Conway Corner	3212	−5
10	"	"	3231	+14	26	30	Willey	3208	−9
11	"	"	3209	−8	27	"	"	3208	−9
12	17	Washington	3216	−1	28	"	"	3235	+18
13	"	"	3222	+5	29	34	Iron	3226	+9
14	"	"	3222	+5	30	"	"	3210	−7
15	22	Lafayette	3232	+15	31	"	"	3210	−7
16	"	"	3207	−10					

Readings 2, 4, 7, 8, 11, 16, 18, 24, 25, 28, 30, and 31 were made upon North Moat from the station named in the third column. The other readings were made from North Moat. No. 5 was made upon the cupola of the house on Kearsarge (N.), and No. 12 on the ridge of the house on Mt. Washington. The first approximation of 3,220 feet, as given in the fourth column of Table III., was derived from Nos. 3, 4, 12, 13, 14, and 25.

Three series of observations were made from the Plaisted House. One, from the piazza, Station No. 2, included the greater portion of the view not cut off by Mt. Starr King. The second from the window, Station No. 3, included a large number of points upon the Mt. Washington Range. The third, also from Station No. 3, is the only one included in Table III. Eight series of observations were made, on seven different days, to determine the effect of the variations in the atmospheric refraction, and other sources of error. In all, 171 settings were made on twenty-seven objects. On taking residuals four were found to be discordant, and to give the values of + 10, − 6, + 11, and − 10 divisions of the micrometer.

Three of these occurred in the second series. All were probably due to errors of reading of the screw-heads, and were doubtless due to carelessness. Of the other residuals but one, which equals 3, exceeds two divisions. The average value of all the residuals is 0.86, or, rejecting the four discordant readings, 0.60. One division varies from two to seven feet, according to the distance of the object. Its average value is about 4.5 feet. A considerable portion of the remaining error is caused by neglecting the tenths of a division. Evidently, for the distances here employed, not exceeding twenty miles, the variations from day to day are inappreciable.

Table V. gives separate residuals for the seven occupied stations observed from the Plaisted House. The number and name of the station are followed by its distance in kilometres, the corresponding value of one division in feet, the mean reading, and the residuals found by subtracting this mean from the individual measures. The residuals are expressed in feet, negative residuals being indicated by Italics. The separate readings for Owl's Head would therefore be 9.31, 9.31, 9.32, 9.31, 9.31, 9.29, and 9.31. The last three columns give the deduced difference in height; the height of the Plaisted window, found by subtracting this difference from the adopted heights of the various stations given in Table III.; and finally, the residuals found by subtracting the mean height, 1,406, from the separate determinations.

TABLE V. — 3. Plaisted House (Window).

No.	Name.	Dist.	1 Div.	Rdg.	Resid.	Diff.	Elev.	Res.
10	Owl's Head	8.65	1.96	9.31	0010020	1846	1426	+20
11	Adams	17.85	4.05	10.71	00*1*01*1*110	4421	1400	−6
16	Pleasant	21.7	4.93	6.61	*11*2100*11*	3376	1404	−2
17	Washington	20.97	4.76	10.11	061100	4921	1407	+1
18	Jefferson	17.50	3.97	10.72	0001*1*10*1*	4338	1401	−5
22	Lafayette	31.3	7.11	5.10	010*11*2001*1*1	3860	1408	+2
30	Willey	26.05	5.92	4.65	*1*00011001	2915	1394	−12

It will be seen that the errors of the individual readings are far less than the systematic errors affecting the whole. Thus the separate values of the height as deduced from the settings

upon Owl's Head, are 1,426, 1,426, 1,424, 1,426, 1,426, 1,430, and 1,426, since one division equals 1.96 feet, and a positive residual denotes a large reading, and consequently a large difference in height of the two stations. As these values are all much in excess of those given by the other stations, it is probable that the assumed distance of Owl's Head is a little too great, or that some other similar error affects them all.

Where values had been adopted for the heights of the occupied station, the reduction of the various measures was easily effected.

The original readings of the micrometer screw were corrected for the position of the axis of the instrument and level, by subtracting the readings when the bubble was in the centre of the tube. A correction was at the same time applied for the inclination of the axis, when level readings in different azimuths showed that this was required. All these corrected readings were written in journal form, placing together all the observations taken from a given point. Ledgers were next prepared, which were formed while making the map, bringing together all the readings upon a given object, and entering the name of the station from which the observation was made, and its distance in kilometres and hundredths. The identification of the point was secured from the horizontal angle. The micrometer readings were next increased by two divisions, to correct for the collimation and level errors, and by a number of divisions equal to the distance in kilometres, to correct for the curvature of the earth and refraction. The distance in kilometres was next multiplied by 0.227, which gave the value in feet of one division of the screw, at a distance equal to that of the observed point. The product was then multiplied by the corrected micrometer reading, and gave the height of the observed point above the instrument. Adding to this the height of the station occupied gave the required height of the observed point. The simplicity of the operation is shown by the formula

$$A = 0.227\ k\ (r - l + 2 + k) + B,$$

in which A is the required height, k the distance in kilometres, r the original reading of the micrometer, l its reading

when the bubble is level, and B the height of the occupied station.

The actual process is shown in Table VI., which gives the determination of the points measured on J. 3, Mts. Bond and Guyot. The figures are copied directly from the original computation, which was made nearly in this form. The successive columns give the number and name of the station from which the observation was made, the distance in kilometres, and the original reading after correcting it for the level. The next column gives the reading corrected for curvature, refraction, collimation, and level by adding to it two *plus* the number representing the distance in kilometres. The sixth column gives the distance in kilometres multiplied by 0.227, and equals the value in feet of one division of the micrometer head at that distance. The product of the fifth and sixth columns is given in the seventh column, after multiplying by 100. The next column gives the assumed height of the point of observation taken from Table I. The sum of these two, or the corrected height, is given in the ninth column; and the last column gives the residual found by subtracting the mean value from the individual values. This mean value is given in the heading following the name of each object observed.

Two additional measures were made, one from Mt. Pleasant, the other from Mt. Jefferson. The azimuth was nearly that of J. 3.4, but the altitude showed that a nearer point on the main ridge was probably observed.

TABLE VI. — Mts. Bond and Guyot.

No.	Name.	Dist.	Rdg.	Corr. Rdg.	1 Div.	Diff. Elev.	Elev. Base.	Elev.	Res.
			J. 3.1. Bond. 4709.						
18	Jefferson	23.87	−2.16	−1.90	5.42	1030	5736	4706	−3
22	Lafayette	9.03	−2.79	−2.68	2.05	549	5269	4720	+11
"	"	"	−2.79	−2.68	"	549	"	4720	+11
25	N. Moat	28.53	+2.04	+2.34	6.36	1488	3217	4705	−4
26	S. Moat	30.83	+2.40	+2.73	7.00	1911	2788	4699	−10
30	Willey	9.36	+1.73	+1.84	2.12	390	4312	4702	−7
"	"	"	+1.76	+1.87	"	396	"	4708	−1

TABLE VI. *Continued.* — MTS. BOND AND GUYOT.

No.	Name.	Dist.	Rdg.	Corr. Rdg.	1 Div.	Diff. Elev.	Elev. Base.	Elev.	Res.
			J. 3.1 b. N. BOND. 4676.						
15	Kearsarge (N.)	35.42	+1.37	+1.74	8.04	1399	3270	4669	−7
18	Jefferson	23.80	−2.24	−1.98	5.40	1069	5736	4667	−9
22	Lafayette	8.84	−2.94	−2.83	2.01	569	5269	4700	+24
23	Liberty	9.68	+0.80	+0.92	2.20	202	4472	4674	−2
25	N. Moat	28.31	+1.96	+2.26	6.43	1453	3217	4670	−6
30	Willey	9.43	+1.58	+1.69	2.14	362	4312	4674	−2
"	"	"	+1.59	+1.70	"	364	"	4676	0
			J. 3.2. S. GUYOT. 4583.						
15	Kearsarge (N.)	35.90	+1.25	+1.63	8.15	1328	3270	4598	+15
16	Pleasant	16.95	−0.72	−0.53	3.85	204	4781	4577	−6
18	Jefferson	23.19	−2.45	−2.20	5.26	1157	5736	4579	−4
22	Lafayette	8.56	−3.60	−3.49	1.94	677	5269	4592	+9
25	N. Moat	29.09	+1.75	+2.06	6.60	1360	3217	4577	−6
30	Willey	9.37	+1.15	+1.26	2.13	268	4312	4580	−3
"	"	"	+1.15	+1.26	"	268	"	4580	−3
			J. 3.3. N. GUYOT. 4589.						
15	Kearsarge (N.)	35.70	+1.22	+1.60	8.10	1296	3270	4566	−23
16	Pleasant	16.64	−0.68	−0.49	3.77	185	4781	4596	+7
22	Lafayette	8.82	−3.43	−3.32	2.00	664	5269	4605	+16
25	N. Moat	28.99	+1.77	+2.08	6.58	1367	3217	4584	−5
26	S. Moat	31.87	+2.14	+2.48	7.23	1793	2788	4581	−8
30	Willey	9.10	+1.27	+1.38	2.07	286	4312	4598	+9
"	"	"	+1.25	+1.36	"	282	"	4594	+5
			J. 3.4. —— 4528.						
22	Lafayette	7.75	−4.30	−4.20	1.76	739	5269	4530	+2
23	Liberty	8.57	+0.19	+0.30	1.95	58	4472	4530	+2
25	N. Moat	29.20	+1.65	+1.96	6.63	1299	3217	4516	−12
27	Chocorua	31.07	+1.13	+1.46	7.05	1029	3508	4537	+9
			J. 3.5. S. BOND. 4279.						
15	Kearsarge (N.)	35.75	+0.86	+1.24	8.11	1006	3270	4276	−3
22	Lafayette	8.55	−5.20	−5.09	1.94	987	5269	4282	+3
23	Liberty	8.53	−1.13	−1.02	1.94	198	4472	4274	−5
25	N. Moat	28.15	+1.35	+1.65	6.39	1054	3217	4271	−8
27	Chocorua	29.70	+0.84	+1.16	6.74	782	3508	4290	+11
30	Willey	10.58	−0.25	−0.12	2.40	29	4312	4283	+4
34	Iron	24.05	+2.56	+2.82	5.46	1540	2736	4276	−3

TABLE VI. — *Concluded.*

No.	Name.	Dist.	Rdg.	Corr. Rdg.	1 Div.	Diff. Elev.	Elev. Base	Elev.	Res.
				J. 3.6. —— 3904.					
18	Jefferson	26.10	−3.40	−3.12	5.92	1847	5736	3889	−15
22	Lafayette	8.50	−7.08	−6.98	1.93	1347	5269	3922	+18
23	Liberty	8.04	−3.23	−3.13	1.83	573	4472	3899	−5
30	Willey	11.20	−1.73	−1.60	2.54	406	4312	3906	+2

The heights of a large number of points were determined by the micrometer level. A portion of the readings has been reduced, some of the objects not having been identified, and the horizontal positions of others not having been determined as yet. Table VII. gives the altitudes of those points which have been determined by measurements from a sufficient number of stations to warrant their publication. The first column gives the Appalachian designation of the point, the second its name, and the third the number of stations from which the height is determined. The fourth column gives the mean value of the height, and the fifth its probable error as indicated from the accordance of the individual readings.

TABLE VII. — Adopted Heights.

Desig.	Name.	No.	Height	P.E.	Desig.	Name.	No.	Height	P.E.
D. 4.2	Pilot	5	3738	1	E. 4.2	Owl's Head	22	3270	1
6.2		8	4186	3	5.2 b		2	1836	0
11.1		3	3916	1	7.2	Dalton	2	2181	2
12.1	Starr King	16	3925	1	9.1	Bray's Hill	10	1633	2
12.3	" "	2	3632	1	F. 2.1	Madison	8	5381	4
12.3 b	" "	5	3325	2	3.1	Adams	27	5819	1
13.1		6	4046	4	3.2	"	4	5615	7
13.2		5	4033	2	3.3	"	3	5431	5
14.1	Pliny	3	3651	6	3.4	"	4	5386	6
16.1	Ball	10	2233	3	4.1	Jefferson	24	5736	1
18.1	Crescent	4	3322	3	5.1	Clay	9	5554	4
18.2	"	3	3246	5	5.2	"	5	5535	2
E. 1.1	Dartmouth	6	3768	3	5.2 b	"	7	5514	2
1.5	Mitten	2	3118	8	5.2 c	"	4	5507	3
3.1	Deception	7	3701	2	6.1	Washington	–	6293	–
3.2	"	4	3722	2	6.2	Boott's Spur	4	5529	4
3.3	"	4	3638	8	7.1	Monroe	6	5397	3
4.1	Cherry	9	3600	2	7.1 b	"	12	5375	6

TABLE VII. — *Continued.*

Desig.	Name.	No.	Height	P.E.	Desig.	Name.	No.	Height	P.E.
F. 7.2	Monroe	13	5216	3	K. 2.1	Tom	6	4078	1
8.1	Franklin	6	4923	2	3.1	Field	11	4355	1
8.2	"	3	5013	3	3.2	"	2	3760	2
9.1	Pleasant	27	4781	1	4.1	Willey	21	4313	2
9.1 b	"	3	4499	3	4.1 b	"	5	4242	4
10.1	Clinton	7	4331	1	6.1	Nancy	9	3944	2
11.1	Jackson	7	4076	4	6.2	"	8	3742	2
12.1	Webster	7	3928	2	7.1	Anderson	8	3748	2
G. 2.1	Bald	5	3752	4	8.1	Lowell	7	3765	3
3.1	Moriah	4	4065	4	9.1	Carrigain	15	4701	1
5.1	Carter	4	4573	2	9.2	"	7	4276	3
5.2	"	5	4614	2	9.3	"	5	3886	4
5.3	"	3	4650	4	9.4	"	9	4435	4
5.3 b	"	4	4640	8	L. 4.1	Giant Stairs	4	3512	2
5.4	"	3	4468	1	5.1 b	Resolution	3	3436	1
6.1	Carter Dome	9	4856	4	6.1	Crawford	5	3130	5
6.2	" "	8	4711	3	8.2	Parker	5	3015	5
H. 1.1	S. Baldface	8	3590	2	9.2	Langdon	3	2439	3
1.2	N. Baldface	8	3608	2	14.1	Iron	10	2736	3
1.5		4	2954	2	M. 1.1	Wildcat	7	4428	3
1.5 b		5	2896	3	1.1 b	"	3	4334	2
2.1	Eastman	9	3559	3	1.2	"	5	4284	2
3.1	Sable	7	3377	4	1.3	"	3	4097	5
4.1	Royce	5	3117	4	4.1	N. Doublehead	8	3072	3
4.2	"	4	3219	5	4.2	S. Doublehead	5	2946	3
I. 1.1	Cannon	5	4107	8	4.2 b	" "	5	2950	3
1.2	"	2	3898	7	N. 1.1	Hancock	6	3906	9
2.2	Kinsman	3	4377	7	1.2	"	6	4284	4
2.5	Pemigewasset	6	2561	4	1.3	"	4	4259	4
4.1	Moosilauke	13	4810	3	1.4	"	8	4434	3
J. 1.1	Hale	3	4102	7	1.5	"	5	4056	3
2.1	N. Twin	11	4783	2	2.1 b	Huntington	4	3731	3
2.1 c	" "	4	4626	2	2.2	"	4	3728	2
2.1 d	" "	5	4316	2	2.3	"	3	3320	8
2.1 e	" "	2	3808	0	4.1	Scar Ridge	6	3815	4
2.2	S. Twin	10	4922	2	4.1 b	" "	4	3536	5
2.2 b	" "	3	4801	6	4.2	" "	5	3816	4
2.4	" "	7	4741	3	5.1	Osceola	10	4204	7
2.5	" "	4	4632	3	5.2	"	12	4352	2
3.1	Bond	7	4709	2	5.4	"	7	4259	2
3.1 b	"	7	4676	2	5.5	"	8	4162	2
3.2	S. Guyot	7	4583	2	5.6	"	5	3651	2
3.3	N. Guyot	7	4589	4	5.7	"	5	3658	3
3.4	W. Bond	4	4528	3	8.1	Tecumseh	7	4008	1
3.5	S. Bond	7	4279	2	O. 1.1	N. Moat	31	3217	2
3.6		4	3904	5	1.2	Red Ridge	5	2787	5
4.1	Haystack, or Garfield	8	4520	3	1.3	Bear Peak	5	2807	4
6.1	Lafayette	31	5269	2	1.4	S. Moat	20	2788	2
6.1 b	"	9	5021	4	2.1	Attitash	2	2516	0
6.2	N. Lafayette	8	5075	4	3.1		5	2985	3
6.3	Lincoln	13	5098	2	3.2	Table	4	2726	7
7.1	Liberty	20	4472	2	3.4		3	2949	3
8.1	Flume	6	4340	3	3.5		3	2953	2
11.1	Agassiz	6	2401	5	4.1	Bear	5	3267	4
11.2	Round Hill	4	2442	9	4.1 b	"	4	3271	2
					4.2	"	3	3225	2

TABLE VII. — *Concluded.*

Desig.	Name.	No.	Height	P.E.	Desig.	Name.	No.	Height	P.E.
O. 4.3	Bear	3	3004	4	3.1	Passaconaway	9	4116	2
5.1	Silver Spring	8	3001	3	3.2	"	4	3402	6
6.1	Tremont	7	3399	4	4.1	Whiteface	8	4057	3
6.2	"	5	3307	8	4.2	"	7	4008	5
6.3	"	5	3010	5	6.1	Tripyramid	8	4189	1
7.1	Green's Cliff	4	2972	4	6.2	"	8	3634	5
P. 1.1	Kearsarge (N.)	45	3270	1	6.3	"	10	4155	3
1.2	Bartlett	6	2650	5	6.4	"	8	4139	2
1.5		3	2628	7	6.5	"	5	3935	3
Q. 1.1	Chocorua	30	3508	1	6.6	"	5	3908	3
1.3	"	8	3375	5	6.7	Kancamagus	4	3774	2
1.4	"	8	3354	3	8.1	Sandwich			
1.5	"	5	3287	5		Dome, or	5	3999	3
2.1	Paugus	7	3248	6	8.2	Black	5	3990	1

In the preparation of this table it appeared that numerous additional heights could be given if the height of Station No. 29 on Thorn Mountain was known. It was accordingly deduced from readings on fifty-four other points, most of them not occupied stations. The mean of these values was 2,283 feet, with an average deviation of 10.7 feet, and a probable error of 1.3 feet. This was adopted as the height of the station on the western ledge, and not of the top of the mountain.

To Mr. Edmands I am indebted for much assistance in relation to the horizontal distances and identifications involved in this work.

From Table VII. it appears that the principal group of the White Mountains is that culminating in Mt. Washington, 6,293 feet. It also contains Mt. Adams, 5,819; Mt. Jefferson, 5,736; Mt. Clay, 5,554; Mt. Monroe, 5,396; Mt. Madison, 5,381; Mt. Franklin, 4,923; Mt. Pleasant, 4,781; Mt. Clinton, 4,331; Mt. Jackson, 4,076; and Mt. Webster, 3,930 feet. The Franconia group contains Mt. Lafayette, 5,269; Mt. Lincoln, 5,098; Mt. Liberty, 4,472; Mt. Flume, 4,340; and Haystack, or Mt. Garfield, 4,520 feet. The Twin Range contains S. Twin, 4,922; N. Twin, 4,783; Mt. Bond, 4,709; Mt. Guyot, 4,589 feet. The Carter Range contains Carter Dome, 4,856; Mt. Carter, 4,650; and Mt. Moriah, 4,065 feet. The Whiteface Range contains Tripyramid, 4,189; Mt. Passaconaway, 4,116; Whiteface, 4,057; and Sandwich Dome (or Black Mountain), 3,999 feet.

Of the other mountains, may be mentioned Mt. Moosilauke, 4,810; Mt. Carrigain, 4,701; Mt. Hancock, 4,434; Mt. Wildcat, 4,428; Mt. Kinsman, 4,377; Mt. Field, 4,355; Mt. Osceola, 4,352; Mt. Willey, 4,313; Mt. Starr King, 3,925; Cherry Mountain, 3,600; Mt. Chocorua, 3,508; Mt. Kearsarge (N.), 3,270; and N. Moat, 3,217 feet.

Boston Public Library
Central Library, Copley Square

Division of
Reference and Research Services

The Date Due Card in the pocket indicates the date on or before which this book should be returned to the Library.

Please do not remove cards from this pocket.

(Mar., 1890, 20,000)

BOSTON PUBLIC LIBRARY.

One volume allowed at a time, and obtained only by card; to be kept 14 days (or seven days in the case of fiction and juvenile books published within one year) without fine; not to be renewed; to be reclaimed by messenger after 21 days, who will collect 20 cents besides fine of 2 cents a day, including Sundays and holidays; not to be lent out of the borrower's household, and not to be transferred; to be returned at this Hall.

Borrowers finding this book mutilated or unwarrantably defaced, are expected to report it; and also any undue delay in the delivery of books.

*** No claim can be established because of the failure of any notice, to or from the Library, through the mail.

The record below must not be made or altered by borrower.